DOCUMENT RESUME

ED 076 242 PS 006 450

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TITLE Mapping Children--Mapping Space.
PUB DATE Sep 72
NOTE 35p.; Paper presented at the Annual Convention of the American Psychological Association (80th, Honolulu, Hawaii, September 2-8, 1972)

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS *Cognitive Development; *Cognitive Processes; *Concept Formation; Infant Behavior; *Kinesthetic Perception; Literature Reviews; *Map Skills; Preschool Learning; *Space Orientation; Speeches

ABSTRACT

Research is underway concerning the way the perception, conception, and representation of spatial layout develops. Three concepts are important here--space itself, frame of reference, and cognitive map. Cognitive map refers to a form of representation of the behavioral space, not paired associate or serial response learning. Other criteria distinguish cognitive maps from models. The beginning of cognitive maps or structured space can be seen in the organization of tactual kinesthetic space in the young infant, as a study of the development of thumb-sucking has shown. Data on children's cognition of spatial layout has been obtained from studies concerning how children orient themselves in familiar space. An observed inability of preschoolers to describe what is above and below a given room may suggest an inadequate cognitive map or a problem in manipulating spatial representations. To measure the precision of cognitive maps, a triangulation technique was developed in which a child had to point in the direction of an object with an unobstructed view of it, with view obstructed but with station points inside the room, and with view obstructed by walls but with station points outside the room. Other studies were conducted with spatial orientation in a new environment and with map reading. Many studies have been done on frame of reference, but little has been done in describing the frame of reference used in orienting objects relative to spatial layout. Techniques are being sought to more directly investigate frames of reference in use at a given moment. (KM)

Mapping Children--Mapping Space[1] [2]

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Imagine a child with two cutout rectangles in front of him. One represents his own room, one the kitchen in his home.

E: Pretend that your mom is calling you down to the kitchen. She wants you to come down to the kitchen and you're up in your bedroom. Can you tell us how you would get from your bedroom to the kitchen?

S: O.K., you open that door and then you have a stairs going down.

E: Oh, is the stairway right by your room? Or do you have to go past some other rooms before you get to the stairway?

S: No, we have to go past two storage rooms.

E: Two storage rooms. O.K., and then you go down the stairway, huh? What do you do when you get to the bottom of the stairway?

S: Then I can turn that way or that way.

E: What if you turn over there; where do you go?

S: That will go to the bathroom, or my mom's room or in the den.

E: Oh, how do you get to the kitchen then when you get to the bottom of the stairs?

S: Oh, well you just turn that way.

E: That way? And then do you have to go through another room before you get to the kitchen? Is the kitchen right there?

[1] This is a protocol of Steven, age 5 and Marsha, age 21, and gives some of the flavor of what I would like to discuss today.

[2] Paper presented at American Psychological Association Meeting, Honolulu, Hawaii, September 1972.

S: You just turn that way and just go straight and then you'll see the stove and the sink.

E: Oh! You just turn left and go straight. Yeah, and the kitchen's right there. Do you have to turn when you get out of the bedroom to get to the stairway?

S: Well, you go like that and then you got to go down one little step and then you go down.

My discussion concerns spatial layout and how the perception, conception, and representation of spatial layout develops. This investigation is a joint effort of Linda Acredolo, Danny Frankel, Marsha Granseth, Curt McIntyre, Linda Sawin and myself. We don't have the area completely mapped out yet. When I was contacted about giving this talk today, I indicated we were embarking on a voyage and I didn't know how good our navigation would be nor how far we would get. I did know I wanted to reach Hawaii and if the prospective audience were willing to listen to how we were trying to navigate and how big our position errors were, I would be glad to describe the endeavor. While I'm not sure that we've made it to Hawaii, I think we have reached the Farallons (I recently learned that these are a group of islands approximately 50 miles off the Golden Gate Bridge).

My interest in this problem all started when I noticed exceptionally large individual differences in map reading abilities in my family. To avoid being called a male chauvinist pig, let me just say that my wife and I seemed to differ a great deal in our ability to read maps. One of us could only seem to fathom directions and routes with great

difficulty; the other with occasional glimpses of a map, even while driving, could find her or his way with little difficulty. How do such individual differences get started developmentally? To get a feeling for children's approach to map problems, I thought it would be fun to teach a pre-school class how to read maps. Our lab school ha a pretty loose structure, and I convinced a head teacher to let the likes of me take a class section. I made a little map of the classroom on flannel board and attempted to teach children identifications between the shapes on the board and objects in the room and then to follow routes laid out on the map. I was startled to find that about a third of the class coudn't be taught anything at this level since they already could function perfectly. The rest of the class, on the other hand, couldn't seem to grasp the problem at all, and I was not able, in that one session, to communicate anything at all to them.

This abortive attempt occurred three or four years ago, but I didn't seriously begin investigating the area until this past year. My colleagues and I first began considering how to characterize the topic of map reading so that we might ask meaningful questions about it. It immediately became obvious that map reading was at the end of a "long road" of cognitive development which includes perception, conception and representation of spatial layout.

From our armchairs, as a first approximation, we decided we wanted to know how children thought about familiar spaces and new spaces, and how they learned to represent space. Questions of obvious importance in how children think about space include how they orient themselves in space, how they remember where events happen in space, how they structure

space. Questions of obvious importance in how children learn to represent space begin with how they recognize pictures of spatial layout, how they learn to identify schematics of spatial layout with real spaces, etc.--even before dealing directly with the problem of representation.

Three concepts recurred as important in our thinking about this area: the concept of space itself, the concept of frame of reference and the concept of cognitive map. Children and adults seem to have behavioral spaces. These might be defined in terms of the way one operates within the space. Thus, for example, Piaget (1956) speaks of perceptual spaces such as sensory-motor space, postural space, visual space, and tactile kinesthetic space. For older children and adults there would appear to be locomotive spaces, automotive spaces, and perhaps aviomotive spaces as well. That is one thinks in terms of walking from room to room, or through several blocks of a city or a few miles if one is especially ambitious but one does not think ordinarily of walking across the country on one hand or across a chair on the other. Similarly one thinks of flying from San Francisco to Honolulu but not from the Ilikai to the Sheraton. According to Piaget,at least initially the perceptual spaces have nothing more than topological relation of proximity, separation, order, etc. However with development these spaces and the more far reaching spaces as well develop Euclidian, metric properties.

The key features--that is the cardinal objects and principle directions which typically will differ for each type of space can be said to define a frame of reference the discussion of which I will defer till later.

Cognitive map refers to a form of representation of the behavioral

space. Tolman's (1948) original concept of cognitive map is very broad including means-end relationships in general. At least in suggesting applications of the concept to problems of social injustice and clinical problems it seemed he meant it very broadly. On the other hand most of the experimental evidence on which Tolman based his concept derives from studies of spatial problems with rats and is evidence about use of routes and paths. It is this narrower space-related concept of cognitive map which we have found useful in our thinking. Probably because of the strength of the behaviorist tradition of the times, psychologists did not, by and large pursue, Tolman's concept theoretically or experimentally. More recently geographers (e.g., Blaut, McCleary & Blaut, 1970; Stea & Downs, 1970), urban planners (e.g., Carr & Schissler, 1969; Appleyard, 1970) and architects (e.g., Alexander, 1965), have become interested in people's conception of spatial layout. Most of these investigators also seem to conceive of cognitive maps as spatial representations rather than more general plans. For example, Stea and Downs (1970) in introducing an issue of Environment and Behavior state that the "geographic reification of the term 'map' has been accompanied by eidetic reification of 'image'."

In our thinking about cognitive maps it seemed necessary to distinguish such spatial representations from a series of stimulus-response associations which could be utilized to get around an environment; for example, turn right at firehouse, left at the gas station, left at the red house, right at the church . . . etc., and to distinguish cognitive maps from a series of responses which one might use in a maze with uniform choice points: right, left, left, right .... Of course,

psychologists know a great deal about how such paired associate and serial response lists are learned. Fortunately (for our work) less is known about the organization of information into spatial representations. One obvious way to distinguish cognitive maps from such other cognitive representations is to ask people how they think about spaces. Most people seem to report some sort of map-like representation of familiar environments and there are observations that Ss actually spatially scan when asked to indicate such things as how many windows are on the front of their house. On the other hand, Steven's protocol with which I began might be interpreted to suggest a paired-associate or serial-response representation.

Having been reared myself in a behaviorist tradition, I also wanted to find behavioral criteria for distinguishing cognitive maps from other types of cognitive representations such as models. The following criteria seem necessary and may serve as part of a formal definition as well as objective means of identifying cognitive maps: Given any two points in space, A and B, being able to go from A to B implies being able to go from B to A (commutivity principle). Given any three points in space, A, B and C, being able to go from A to C and from B to C implies being able to go from A to B (associativity principle). Given any two points in space, A and B, being able to go from A to B via one route implies being able to go from A to B by other possible routes.

While these criteria seem necessary, they don't seem sufficient. Something like an introspective report of a map-like experience also seems necessary. To clarify this point, let me further distinguish between a cognitive map and model. Psychologists have long been able to

describe man's experience of color in terms of the three-dimensional solid color cone. This spatial representation is a model of our color experience but for most people it is not a cognitive map. That is, it is probably only Titchnerian psychologists who, in thinking about or experiencing colors, imagine them as occupying a particular point in that conical space with a given relation to all other colors. On the other hand, knowing the color cone enables one to move cognitively between colors in a manner suggested by the above behavioral criteria for cognitive maps. Thus the behavioral criteria alone do not seem sufficient.

In the literature, the study most relevant to our criteria for a cognitive map is Maier's (1936) investigation of children's ability to combine two aspects of previous experience. A child is exposed to a maze without reward during one period. He is shown the locus of a reward at one place in a maze during a second period, and he must get to that reward from a different place during the third period. Presumably, the child must build up a cognitive map of the maze during the first period, must remember the specific location of reward during second phase,. and combine those two experiences during the third phase. Maier trained children between 43 and 95 months of age on this problem. There was a slight improvement from 43 to 66 months of age with the highest jump in performance occurring after 66 months of age.

But how early can cognitive maps or structured space be found developmentally? Although we have suggested the commutivity, associativity, and alternate route principles for defining cognitive map, it seems likely that developmentally a prior stage may be getting from any point X in space to a specific point B (but not necessarily back again). The first

observation I would like to report concerns the organization of tactual-kinesthetic space in the young infant. It is an observation from a very detailed case study of the development of reaching completed by Danny Frankel with the help of Dr. Albert Yonas. This part of Frankel's observations concerns the question of how an infant is able to get its thumb into its mouth. Does its behavior suggest the existence of an organized space? Sunny, a female baby, was observed and videotaped at least twice each week for the first four months of life. Observation periods were more frequent when Frankel felt changes in reaching were occurring rapidly. He made very complete protocols at the time of observation and exhaustively studied the videotapes.

The earliest instances of thumb-sucking occurring up to one and a half months of age,appeared to result from random opportunity. At this time the thumb, if it were extended, would frequently drop into the mouth when the head was moving around. However, Sunny was <u>unable</u> to orient her hand or mouth appropriately even if the back of the hand hit her mouth or if the thumb hit the upper gum. By one and a half months, there was some orientation of the mouth. That is, if the thumb hit the teeth or gums, the <u>mouth</u> was moved towards the thumb. Also by this age the hand was often reoriented appropriately if initial contact with mouth was made. At this age, the hand could be moved to the mouth from places as far away as the cheek. It would move towards the mouth but not always by the shortest route. However, it never moved away from the mouth. Between 1 1/2 and 2 months, both directedness of hand motion and mouth movement improved. When the hand hit the face anywhere, the mouth turned towards it and often moved part way. The thumb then tracked in until it got to

the mouth. One gets the impression of the development of a polar coordinate system with the mouth as origin but one in which the origin can move. Frankel's observations then go on to suggest that after development of this very near tactile facial space, there is a development of a similar limb movement space which gets the hand to the mouth from any position in space. This initially also depended on tracking along the skin but then became purely motor or proprioceptive in nature. The suggestion of space developing from near to far and shifting modes is very intriguing. It is clear the the infant develops ability to get his thumb to his mouth from any point in space. These observations are provocative but preliminary. They have been partially replicated with a case study of another infant but they need to be extended and verified more generally. For example, in terms of our additional criteria it would be valuable to know whether and when this ability to get the thumb to the mouth implies an ability to get the hand from any point to any other point within reach.

Most of our own data on children's cognition of spatial layout comes from older children from a series of studies conducted in the Minnesota lab preschool. (These children are a random cross-section of faculty and other professional types.) Two of these studies concern how children orient themselves in familiar spaces. The first study focused on children's memory and knowledge of the spatial layout of their own home. It was conducted in two phases. In the first phase children were asked to select out shapes most like the shape of their own bedroom and the shape of their own kitchen. Then they were asked to place toy furniture at the appropriate place in each of the rooms. For

the bedroom--the furniture was door, closet, window, bed, dresser and lamp. For the kitchen it was door or doors, (usually two), windows (usually two), sink, stove and refrigerator. They were also asked to describe how they would go from their bedroom to the kitchen. (The prologue was taken from one protocol answer to this question.) The children were also asked to pretend they were brushing teeth in front of bathroom mirror. Suppose they could see through the mirror. What would be on the other side? The second phase consisted of a home visit one purpose of which was to check the child's responses about the spatial layout of his room, the kitchen and the route between. The second purpose of the home visit was to question the child as to what was behind two walls of the bedroom, and two walls of the kitchen, i.e., adjacent rooms. (What is on other side of this wall? E points.) The child was also questioned as to what was directly above and/or below kitchen and bedroom. (What is directly above this room, through the ceiling? E points). Finally, the child was taken outside and asked to identify what rooms belonged to each of four windows. Certain difficulties were incurred with the questions about above and below, and the windows, with a couple of children who lived in apartment houses. However, it was possible to carry out these sessions pretty much as described with eight 4-year olds and eight 5-year-olds.

Both age groups did fairly well in identifying the shape of their own room and the kitchen. Each child could get zero, one or two shapes correct. The average was 1.5 for the 5-year-olds and 1.6 for the 4-year-olds. However, placement of objects within the room sharply differentiated the ages. Again, with the two rooms combined, there were typically 14 objects to be placed. The 5-year-olds averaged 76% correct and the

4-year olds 42% correct. There was only one overlapping score. Questions about what was on the other side of walls of the child's room and kitchen also differentiated the ages. With a possible score of four correct, the 5-year-olds averaged 73% correct, while the younger children averaged 53% correct. Neither age group did well on what was above and below the rooms, but both age groups were exceptionally good at identifying windows with rooms, i.e., could stand outside and indicate which room belonged to which window. The worst performance was obtained with both groups for the question about what was behind the bathroom mirror and the question about the route from bedroom to kitchen. In the case of the bathroom mirror, there may have been a problem in conveying to the child what we were interested in. In any case, most answers were wrong and in some cases answers bizarre--e.g., "a mouse." In the case of the route question, there may have been a problem in the child's communicating to us. Most answers were confused, vague and difficult to score. A few answers here too were bizarre--e.g., "By the stairs, past Mommy and Daddy's room, turn that way, after stairs there's a river."

Overall then, both ages do well at identifying the shapes of rooms and identifying windows from the outside with rooms. Neither age did well in stating what was above and below rooms, behind bathroom mirror or in describing the route. Big age differences were found in identifying what was behind walls and in placing objects within the familiar rooms.

As suggested above, the problem with the route and behind-the-mirror questions may have been one of communication. The difficulty of both ages, however, in describing what is above and below a given room

may suggest an inadequate spatial cognitive map. That is, if one had three-dimensional spatial representation of both floors of a house there should be no problem. If one had separate spatial representations of both floors of the house they could be superimposed. However, it would also be possible to have such separate spatial representation ar be able to superimpose them. That is, the problem might be in the manipulation of the spatial representations rather than in their existence. The age difference in knowing what is behind the walls of familiar rooms and remembering where objects are placed in these rooms could be due either to simple improvement in rote memory or a developing spatial representation.

Interest in this study was on knowledge and memory of general spatial layout and no stress was placed on great precision. Indeed, no precise measures were taken. However, we wanted to develop a technique for measuring the precision of cognitive maps. We attempted to adapt a triangulation technique from navigation to do this. One method of determining the position of a boat or ship in coastal waters is to take a bearing on three landmarks whose positions are given on a chart. The bearing or direction lines are extended on the chart back towards the boat position from the landmarks. Where these direction lines intersect is the boat position. We felt that if a child had a cognitive map of an area, he would be able to point in the direction of the object from any point within the area, (even if his view were obstructed), provided he knew where he was. Thus, for any given object in the area the child could point to it from each of three station points (which correspond to the known landmarks in navigating). The intersection of these direction

lines plotted on a map of the area defines the position of the object. A layout of sev - su h object positions plotted on a map of the area comprises a sketch of the child's cognitive map. Precision can be measured by the extent to which the three direction lines intersect in a point rather than form a triangle. It also can be measured by the extent to which the intersection points (or centers of intersection triangles) deviate from the real position of the objects. These two measures are analogous to the traditional measures of reliability and validity.

We employed this method for defining (representing) the cognitive maps of our lab preschool rooms. Four target objects were chosen which roughly formed a rectangle in the room. Direction lines were determined for each of these four objects from three different station points. Children and adults were run under three different conditions: (1) with an unobstructed view (a sort of a base line for optimum performance, (2) with view obstructed by an enclosing screen but with station points inside the room, (3) with view obstructed by walls of room--that is the station points were outside the room--in the building corridor and in the playyard. The actual pointing was carried out by asking S to adjust a sighting tube at the object. This was mounted on a compass rose from which direction could be read. One would expect that the inside unobstructed views would be best, the inside obstructed views next, and the outside obstructed views would be worst. This in general is what was found. The following slides show results of the typical--perhaps ideal--child and the similar results from a <u>negativistic</u> adult.

Slides 1-6

The first slide is an example of the positions of objects determined for inside unobstructed pointing by a child.

The second slide . . .

(Point out cverall shape of room, station points, true object positions, plotted position, triangles, etc.)

Adults would be expected to perform better than children. This was found to be true but only for the extent to which the cognitive map points deviate from the true point locations. The difference between children and adults in the size of their position triangles (reliability measure) was not significant. (This lack of difference might be due to (a) adults less familiarity with room, and/or (b) sloppiness with which adults made alignments particularly in the inside unobstructed view.)

In spite of the relatively large size of the errors, it is clear even for children there were coherent maps plotted on the basis of direction lines obtained from outside the room as well as inside, both obstructed and unobstructed. Children of this age seem to have cognitive maps and keep themselves well oriented to familiar spaces even when they are not directly in view.

Do children always keep themselves oriented in space? Suppose we take a child to a new or an undifferentiated environment. Does he spontaneously tag objects or events with their spatial position? Suppose we ask him to remember the spatial location of events can she do so in the same situation. To examine such questions, our preschool children were taken individually for a walk either through the relatively undifferentiated

corridors of a new building or out into a more differentiated familiar outside play area. The E at some point on the way apparently inadvertently dropped a card she was holding, and the child picked it up. The walk continued for a few moments more (in the new building around a corner) and the child was asked to return to the exact location where the card was dropped. This was a sort of incidental learning task. The child was then taken on to a new location, asked specifically to remember it so he could return to it and then led on for the same distance as for the incidental learning task before being asked to return to his new location. This was analogous to an intentional learning task. These procedures were conducted with a naive group of children and with a group of children who had been given fairly extensive map training (which I'll discuss in a few minutes). Thus, we have some children performing in an undifferentiated novel environment, others in a differentiated familiar environment, some who had had map training and others lacking that experience. All children performed first on the incidental task and then on the intentional task. Results can be seen in the next slide. Errors were measured in inches between where the child indicated the location was and where it really had been. Note first that for all four

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Insert Slide 7 here
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groups, intentional memory was better than incidental. It would be interesting to see if the curvilinear relation between age and incidental learning which a number of investigators have demonstrated (Siegel & Stevenson, 1966; Maccoby & Hagen, 1966) would occur with memory for spatial location. Secondly, the outside familiar differentiated environment is

consistently better than the inside unfamiliar undifferentiated environment. (It was noticed that in the inside incidental task, children tended to place the location closer to a distinctive object--a drinking fountain--than it really was. This would suggest perhaps the importance of differentiation as opposed to familiarity.) We are currently trying to tease apart the effects of differentiation of environment and familiarity. Finally, the map-experienced seem fairly consistently better than the map-naive. It is possible that our map training has sensitized the children to spatial position.

Our map reading program was conducted in collaboration with Ann Carlson, one of our head teachers, who has been particularly interested in the development of this ability in young children. We gave all the children in the class a screening test which involved the ordering of three colored objects. The E arranged checkers of different colors in various orders, and S was required to match these orders with his own checkers of like colors. Ss were grouped for subsequent training on the basis of their performance in the screening test.

The map training was conducted by Mrs. Carlson who took four children aside for 15-minute periods each day. The teaching materials consisted of a 22-inch square model village with wooden houses, colored landscape, etc., a 24-inch square black and white photograph of the village taken from an oblique angle so that the sides of the houses as well as roofs were visible, a 24-inch square aerial photograph of the village taken from directly overhead so that the roofs alone were visible, a 14-inch square map of the village color coded as the original village, and a 16-inch square schematic map of the village with only outline features.

Training began with the easiest task, using the model village and oblique angle photo, and consisted of having the children take turns at following the teacher's instructions. The usual format was as follows:

1) Identification of items in model village. (The teacher asked children to name items which she pointed to on the model.)
2) Identification of items in the oblique photo. (Children named items which teacher pointed to on photo.)
3) Finding item on photo which corresponded to one on model pointed to by teacher.
4) Driving with a toy car from place to place in model village, finding alternative routes, finding shortest routes. (Teacher would say, for example, can you drive your car from this house to the school.)
5) Teacher driving in model village, with child following same route on photo--simultaneously or successively.
6) Orientation. (Teacher would turn photo and child would realign photo with village.)

These steps were repeated for the rest of the "maps" that is the other overhead aerial photo, color-coded map, schematic map in that order. Each child was given one or two turns at each task before the next task was introduced. The fifteen-minute sessions only permitted introduction of one or two maps at each session. The remaining maps were introduced in subsequent sessions with the same children.

During the group training procedure, it was difficult to evaluate whether individual children were learning as they tended to help each other and they also were coaxed into correct answers by the teacher. To

evaluate specifically whether the children had learned how to use the maps of the village they were tested individually on the use of the maps, and compared with a similarly tested untrained group of children.

The test involved the same tasks as had been involved in the training identification of objects in the village, pointing on the various maps to objects indicated by E in the village, orienting the maps so as to match the village orientation, matching routes on maps which E indicated on village, and finding the shortest route between two points. There were clear differences between the trained and untrained groups--overall the trained group averaging about 15% errors, the untrained group 35% errors. The trained group had most difficulty with routes, making 18% errors as opposed to 11% errors on identification of objects on maps with objects on model village, and no errors of orientation. The untrained group made most errors (50%) in identifying objects between map and village--almost as many (40%) in following routes but again very few, 13%, in orienting the map to match the village.

Clearly map training helped performance with these specific maps. Unfortunately, the children were not tested on novel maps and villages. However, in subsequent days small group activity with the trained class included having groups of children make sorties following maps around the campus and into a nearby commercial area. Although these groups were accompanied by adults the children were observed to be able pretty much to navigate on their own. The only experimental evidence we have for transfer to different situations is the suggestion of better performance by the trained children in the incidental--intentional spatial memory study described previously.

It was observed that the overhead aerial photographs of the village was very easy to orient by both naive and map-experienced children, but the map-naive children made many errors of identification. The ease with which the orientation matches were made is reminiscent of Blaut, McCleary & Blaut's (1970) finding that the six-year-old children could identify objects in aerial views of landscapes although their performance was far from errorless. Our naive Ss didn't do very well in identification. However, they were younger than Blaut, McCleary & Blaut's Ss and they did perform better than chance on the identifications although not exceptionally well.

Earlier in the discussion I mentioned three concepts which seemed to be important in our thinking about children's spatial concepts: space itself, cognitive maps, and frames of reference. I mentioned the fact that we were interested in behavioral space and have tried to interpret some of our results in terms of cognitive maps. The one theoretical concept which I have not discussed so far is "frame of reference." In an intuitive sense, it is quite clear that the infant studied by Danny Frankel had a frame of reference for orienting his thumb movements on his face, it is clear that the drinking fountain served as some sort of a reference point for Ss in our task intentional-incidental memory for spatial location, and it is clear the the SS in our triangulation study, when pointing at objects with view obstructed or from outside the room were operating within a frame of reference. But in a more abstract sense, what is a frame of reference? One possible definition would be a set of interrelated coordinate points (and perhaps directions) with respect to which new points are locatd. A very simple frame of reference

would be one cardinal point with simply scalar distance (near-far) from it noted. Of course frames of reference can get very complex with abstract coordinate systems, and various cardinal points.

The best known study of frames of reference is probably that of Piaget's three mountain problem (Piaget & Inhelder, 1956). In that Problem, you will recall that the younger children--Stage II, 4-6 years of age--displayed egocentric behavior and chose perspective pictures or reconstructed the spatial position of the models always as if from S's own point of view. This study has been repeated with variations by a number of investigators (Dodwell, 1964; Houssidas, 1965; Lewis & Fishbein, 1969; Laurendeau & Pinard, 1970; and Pufall & Shaw, in press). Pufall & Shaw's study is most instructive from the point of view of an analysis of frames of reference. In their study a child and _E_ each had spatial arrays blocked out on boards. The child's task was to place a small animal exactly in the same position and orientation on his board as _E_ placed an animal on his board. The boards were coded as follows: Each board was divided into four quadrants by a vertical and horizontal mid-line. The quadrants were of different colors and each had a different geometric shape in its center. In the four corners of each quadrant were differently colored pegs. Each side of the perimeter of the board was distinctively visually textured. With the various types of contextual coding, it was possible to make correct (and incorrect) placements of the animal independently in quadrant, corner, and position in corner as well as in the correct or incorrect orientation. That is, a child could place his animal in the wrong quadrant but in the correct corner within the quadrant, but again in the incorrect position within that corner.

Thus. from an analysis of errors, it was possible to obtain some idea of the frame of reference children of different ages are most sensitive to--or conversely. ignored. Children between four and ten served as Ss. Only the four-year-olds made many errors which ignored all the contextual coding. They tended to make many placements on the side of the board closest to E's board. However, once in a particular quadrant, thev tended to get the correct corner within that quadrant but made many errors on position within the corner. Most of these position errors were of an egocentric nature--near, far, right, left of self. By the time children were 10 years old, they were making fewest errors in placing the animal in the correct quadrant but again most, in placing the animal in the correct position within the quadrant. Thus, it seems as if at least in this task,children between four and ten are changing the frame of reference utilized in choosing the quadrant. Errors in <u>orientation</u> of animals were of an egocentric nature for both the younger and intermediate-age children (6 years) while these latter children had already stopped making egocentric errors in location of their animals. Thus it appears as if the intermediate-age children are using an egocentric frame of reference for one task but not another. That is 6-year old children made egocentric errors in orientation but not in location.

The hypothesized pervasive age trend from egocentric to some extrinsic frame of reference must be carefully related to the task. In relation to spatial layout, for example, an extreme form of egocentric response would be response learning as opposed to place learning. This sort of response is very difficult to obtain in animals and although I don't think it's ever been tried, I doubt if it could be obtained in even

young infants. In this connection, Flavell has recently analyzed behavior of children in a variety of tasks trying to get at children's ability to infer precepts of others. His conclusion is that children are much more object-oriented than precept oriented. Thus, they might not be able to describe another's precept because they are too wrapped up in the specific object. In the case of spatial layout, I would suggest that they wouldn't be able to learn a particular response, e.g., turn right or left, because they are too wrapped up in the real position of the object. Also, the recent studies of Lewis & Fishbein suggest that egocentric responding develops after more random responding in task like the three mountain problem.

Another argument against a general attribution of egocentric responding to all primitive organisms is the case of orientation to gravity. The general thrust of Witken's interpretation of his field dependence data is that field dependence decreases with age in a task to adjust a rod to vertical in a tilted surround. Thus, in this case, younger children tend to be more influenced by context and less able to make "egocentric?" responses.

But even assuming that it is correct to attribute an egocentric frame of reference to young children such a description is in general probably too gross. For example, a simple form of egocentric frame of reference would be inside-outside, or near-far, with no further differentiation. Or it could be front-back, up-down, and right-left. C. J. Fillmore (1971) makes the interesting point that for an object such as oneself to have a left and right it has to have a top and bottom and a front and back. His graphi(illustration is of a missile travelling

through space. It's direction of motion gives it a front-back (fore and aft). But since there is no reference system for it to have a top and bottom, it is meaningless to say that it has a right and left or makes a right turn. Thus, a child who orients appropriately with respect to left and right must be appropriately oriented with respect to up-down and front-back.

The main point is that whether we attribute egocentric or non-egocentric reference systems to children we have to go beyond that and analyze what specifically are the interrelated cardinal points and directions which determine the child's response. Psychologists have done at least a fair job in describing some of the frames of reference used by Ss in judging the up-down orientation of objects. I am thinking here of the work of Rock (Rock & Heimer, 1957) and of Ghent (1961), which show that under various conditions Ss will employ a gravitational frame of reference, a visual field frame of reference or a retinal frame of reference. I am also thinking of the recent work of Attneave and his colleagues (Attneave and Olson, 1967; Attneave and Reid, 1968) which indicates that while adults tend spontaneously to use a gravitational frame of reference they can shift in a very fundamental way to using a retinal frame of reference if requested.

However, we psychologists have done a rather poor job in describing the frames of reference used in orienting objects relative to spatial layout. Perhaps this is because the problem is somewhat more complex. With respect to up-down orientation there are several clearly specifiable frames of reference--gravity, visual field, and body. (Of course, the body orientation can be broken down separately into trunk, head, eye position in head, etc. (cf. Howard & Templeton, 1966, for a good discussion

of this.)) With respect to <u>spatial position</u>, as opposed to up-down, there is probably a large set of nested and partially nested frames of reference. If you or I were to identify the spatial position of an object in this room, say that chair, we could do it egocentrically by saying it's to my right and in front of me or by its relation to other objects in the room, by saying it is the left end chair in row closest to the podium, or by its relation to the room as a container, that is, by saying it is in the row closest to the front wall and to the side wall which has no patterning. If you or I were identifying the spatial position of that chair we could do it in relation to other parts of the building by saying it is the chair in the row nearest the Marina Tower at the end nearest the swimming pool, or we could specify it geographically as Hawaiians do, as the chair in the row toward Eva at the end by the makai lanai (the seaward patio) or we could do it geographically by compass by saying it's the chair in the southwest corner. It is quite clear that we adults under particular circumstances might employ almost any one of these many frames of reference, but it is very doubtful if children could. What determines which frames of reference adults use? What is the course of development of ability to utilize various frames of reference? These are the kinds of questions which we are setting out to try to answer now.

It is tempting to hypothesize that one developmental trend in use of frames of reference goes from object relevant to more abstract--extending Flavell's idea and that another trend goes from molecular to molar (e.g., tactile-kinesthetic to aviomotive). We had hoped to gain some insight in the frames of reference children might use by asking them to construct the spatial layout of their own rooms and kitchen at home and the triangulation

study of the pre-school rooms. However, we are seeking techniques which more directly investigate frames of reference in use at a given moment. That is, techniques which let the child tell us what frame of reference he is using rather than picking one frame of reference, e.g., objects, and asking the child to perform with respect to it. If you think back to the various small experiments I described, you will also note that most of them study what children remember about spatial layout. We are also seeking techniques to investigate the direct perception of spatial layout as well as the memory of it. Hopefully we will be able to report landfalls in these directions as our cruise continues.

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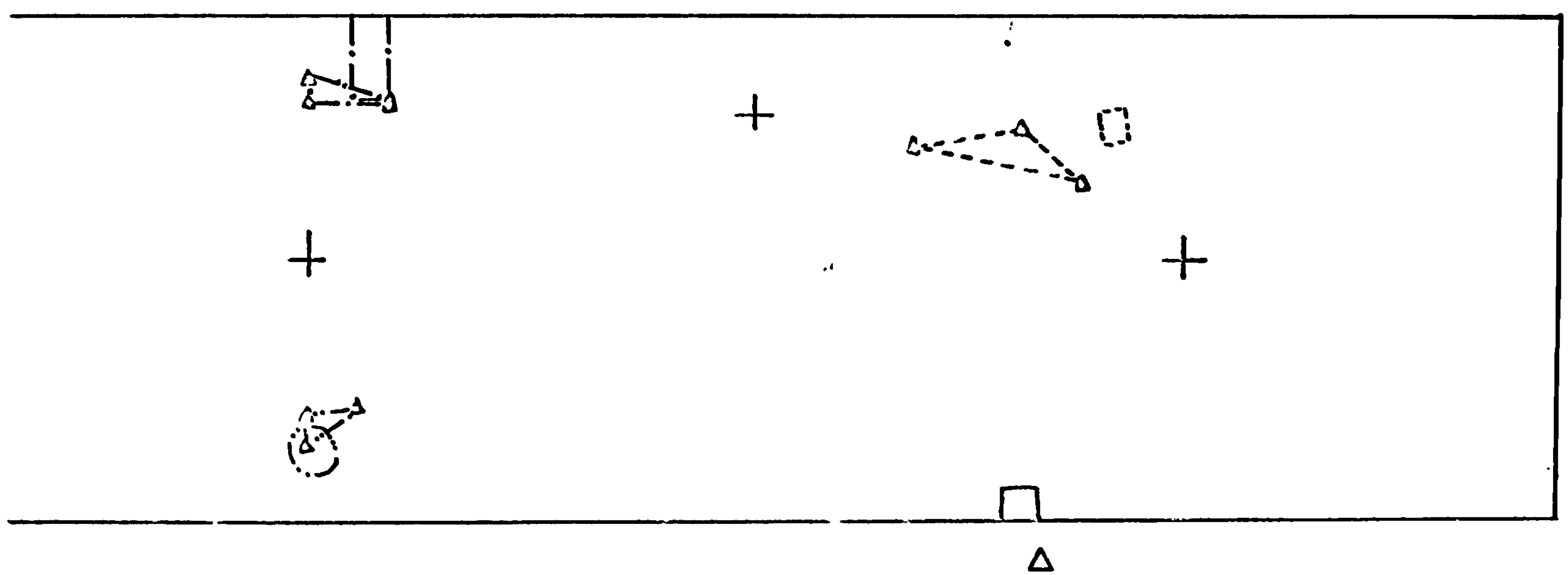
SLIDE O

LEGEND

FOUNTAIN	SCISSORS BOX	STATION POINT +
PIANO	TABLE	

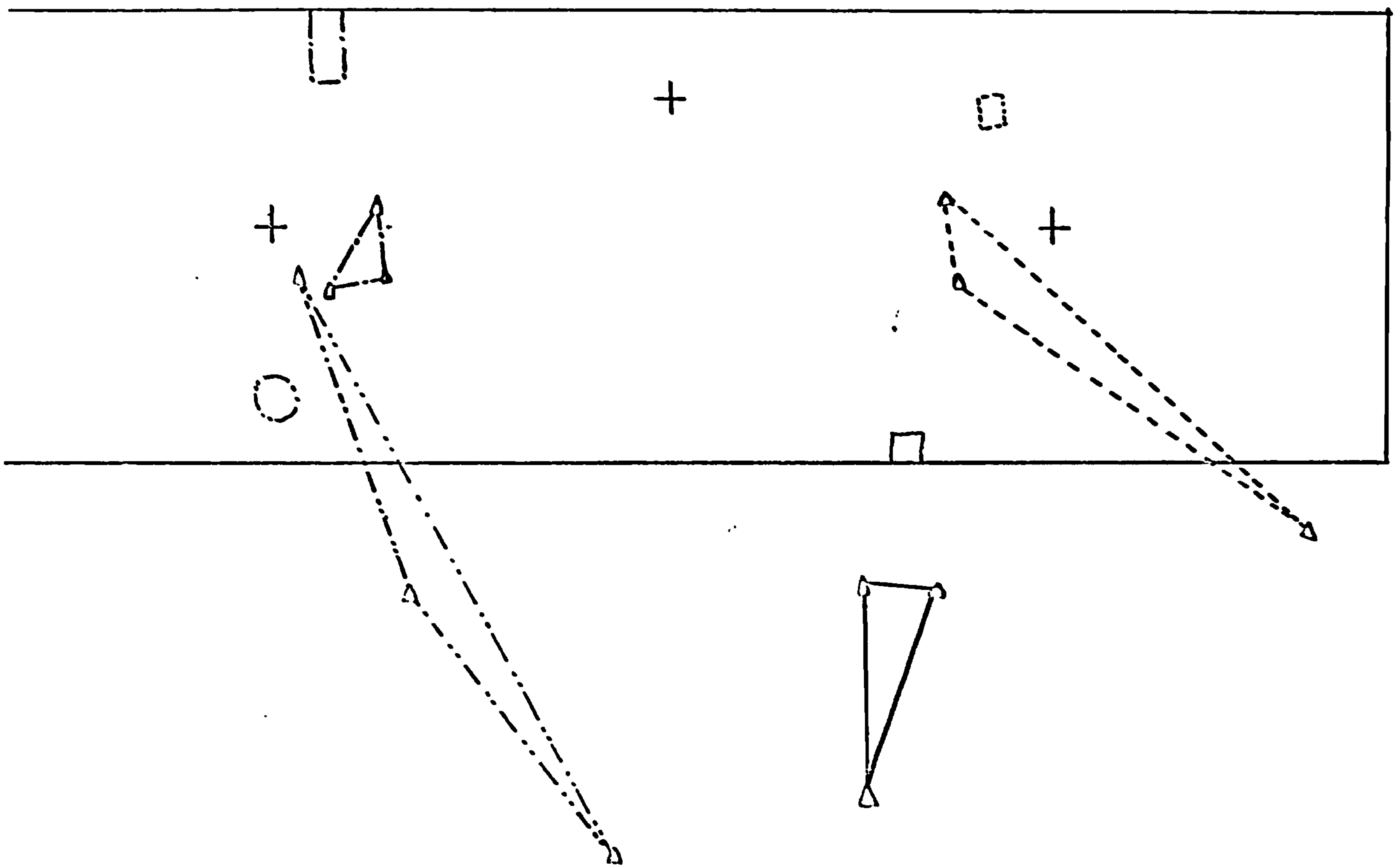
For position triangles which would otherwise fall off the map area an alternative conservative method of plotting positions was used.

SLIDE 1



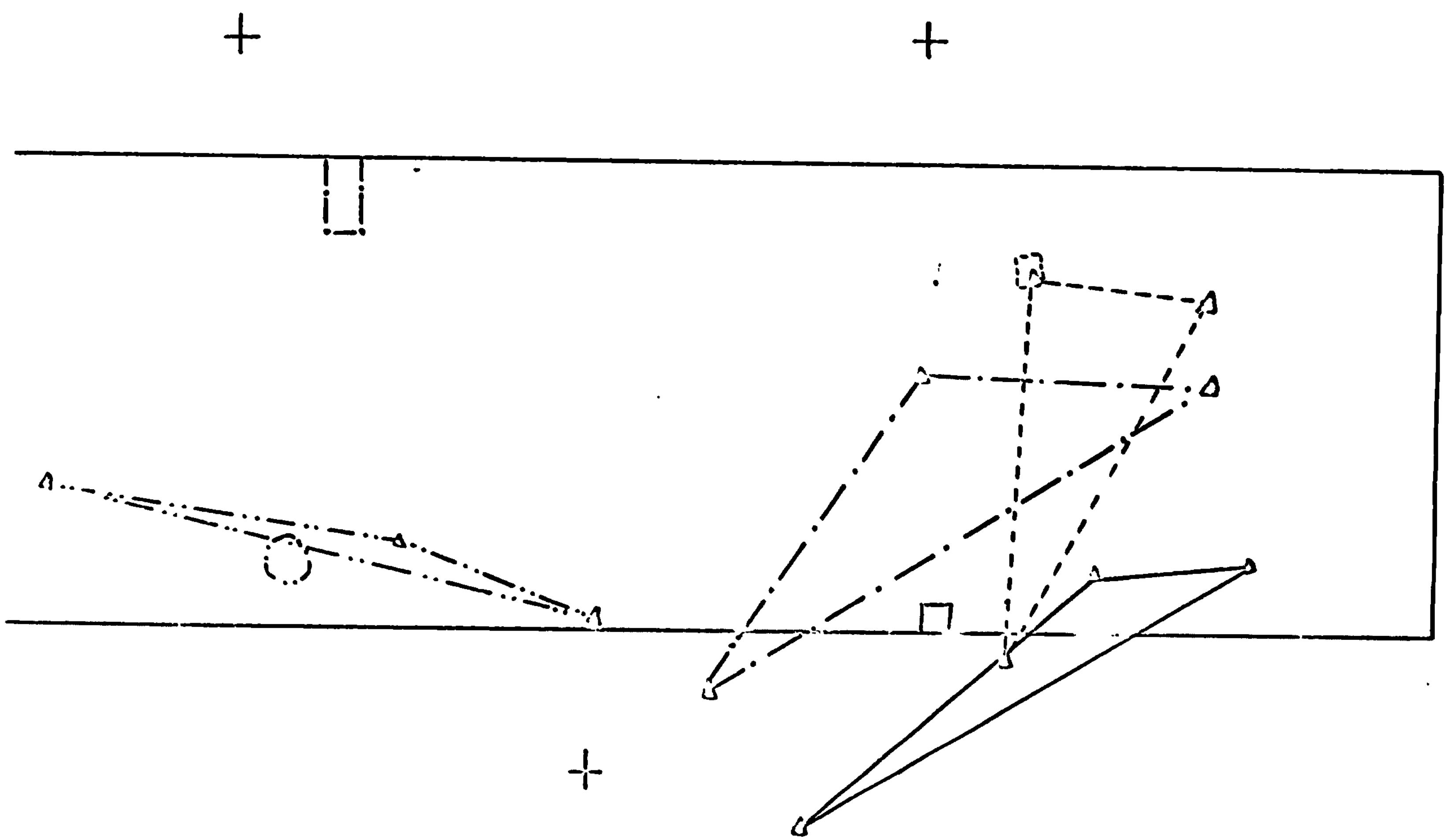
child-inside -
unobstructed

SLIDE 2



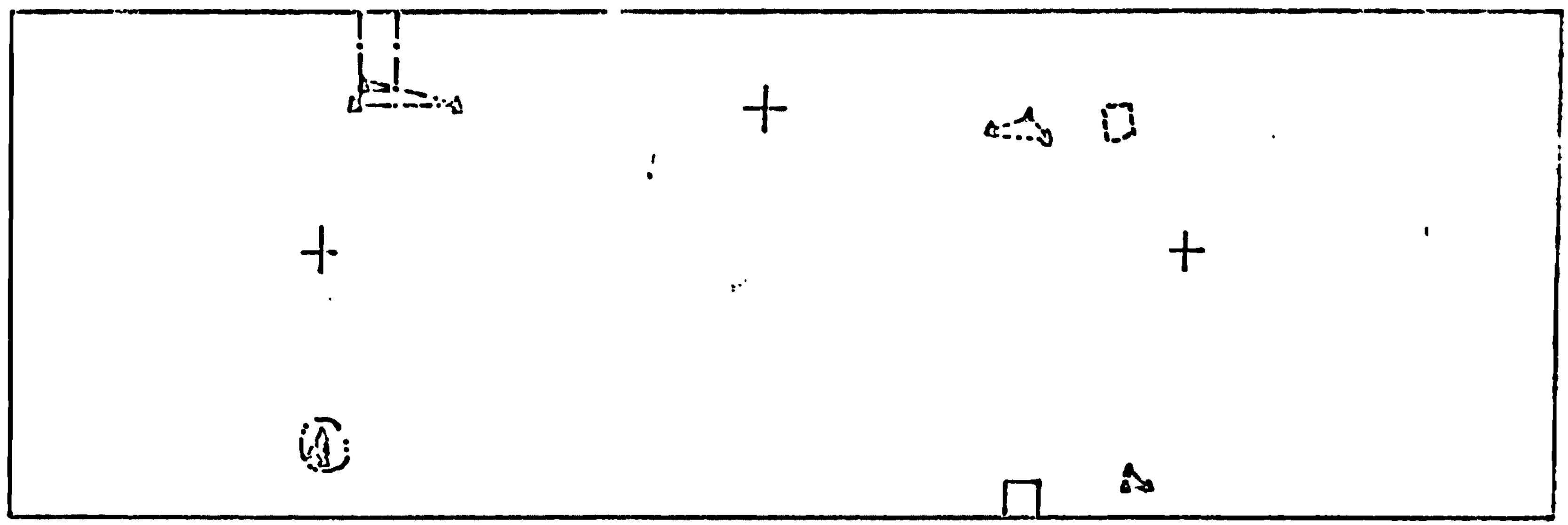
child - [redacted]
inside obstructed

SLIDE 3



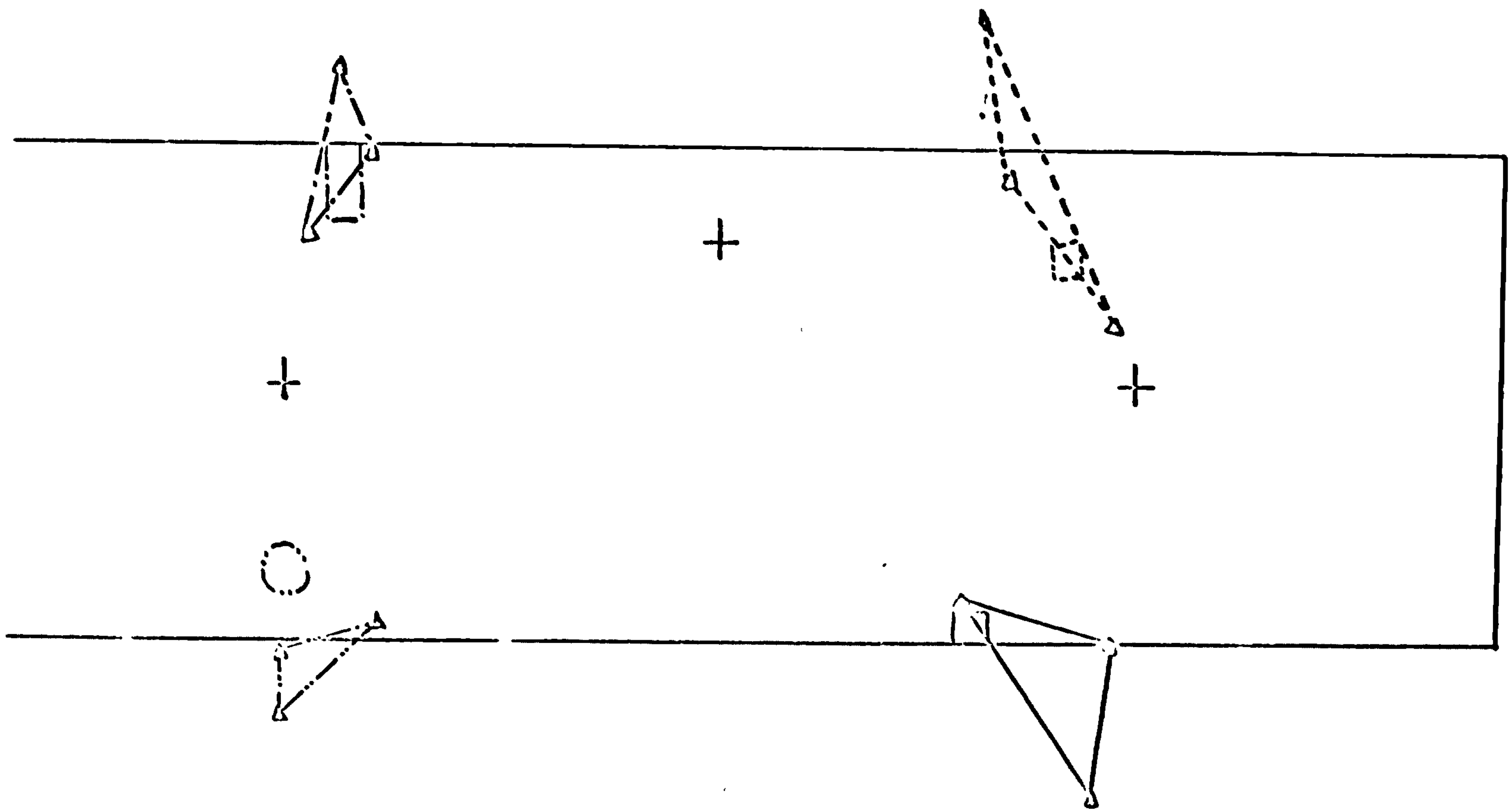
Check - ~~[illegible]~~
Outside Obstructed

SLIDE 4



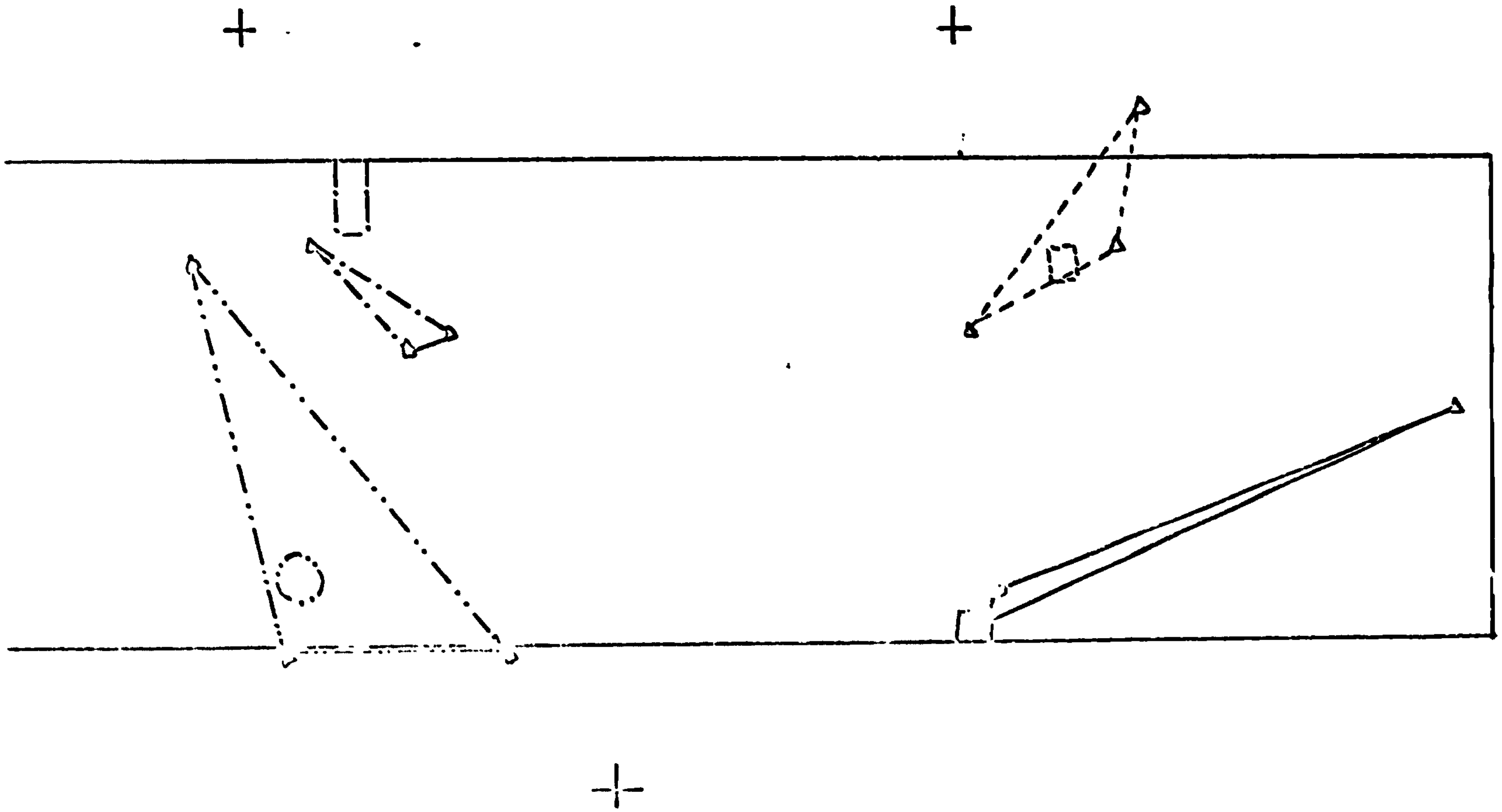
Adult - [redacted]
Inside-Unobstructed

SLIDE 5



Acuity
inside - obstructed

SLIDE 6



Adult -
Outside Obstacles

SLIDE 7

Errors (in inches)

Outside-map experienced

	Incid.	Intent.
1.	12	0
2.	10	0
3.	25	0
4.	0	0
5.	23	12
6.	0	0
Total	70	12
Average	11.67	2

Outside-map naive

	Incid.	Intent.
13.	13	7
14.	13	6
15.	84	18
16.	24	0
17.	21	0
18.	29	22
Total	184	53
Average	30.67	8.83

Inside-map experienced

	Incid.	Intent.
7.	117	9
8.	63	45
9.	81	81
10.	477	9
11.	9	45
12.	9	108
Total	756	297
Average	126	49.5

Inside-map naive

	Incid.	Intent.
19.	648	9
20.	117	0
21.	225	9
22.	72	54
23.	9	198
24.	603	18
Total	1674	288
Average	279	48